Research Project co-funded by the
European Commission
Research Directorate-General
5th Framework Programme
Energy, Environment and Sustainable Development
Contract No. EVK3-CT-2002-00075
Project home page: http://www.bo.ingv.it/mfstep

Mediterranean ocean Forecasting System:

Toward Environmental Predictions

MFSTEP

Executive summary

(1 March 2003 – 31 May 2006)

Co-ordinator:

Istituto Nazionale di Geofisica e Vulcanologia, Italy

Authors: Nadia Pinardi, Giovanni Coppini and MFSTEP Partners

Objectives: The Project aims at the further development of an operational forecasting system for the Mediterranean Sea based upon three main components: a) a Real Time-RT Observing system; b) a numerical forecasting system at the basin scale and for the sub-regional/shelf areas; c) the forecast products dissemination/exploitation system.

The Observing system component consists of:

- a SOOP-VOS system with RT data dissemination and test of new sensors that collect multidisciplinary data;
- a moored buoy network (M3A) designed to serve the RT validation of the basin scale models and the calibration of the ecosystem models;
- a satellite RT data analysis system using several satellites for sea surface elevation, sea surface temperature and sea surface winds;
- a high space-time resolution network of autonomous subsurface profiling floats (Array for Real-Time Geostrophic Oceanography-ARGO);
- a basin scale glider autonomous vehicle experiment;

The sampling strategy is continuously assessed by the Observing System Simulation Experiment (OSSE) activities and a RT data management and delayed mode archiving system has been organized.

The Modelling system is composed of:

- the development of optimal estimation techniques for basin scale and shelf area models;
- the production of a 10-day basin scale forecasting at approximately 6 km resolution with initialization from all RT observations available during a Targeted Operational Period-TOP;
- the production of 5-day forecasts at high resolution (3 km) in four regions: North-Western Mediterranean, Sicilian Strait, Adriatic Sea and Levantine-Aegean Sea (the Adriatic Sea is sponsored by an Italian national project which however shares data and techniques with MFSTEP); the implementation of 11 shelf models (1,5 km resolution) nested in the sub-regional models, (Gulf of Lion, Catalan Shelf (1), Catalan Shelf (2), Malta Shelf, N. Adriatic Shelf, N. Aegean, Cretan Sea, Cyprus Coastal Ocean Model, Cilician Basin, SE Levantine Shelf)

- the RT production and dissemination of operational weather forecasts for the basin scale (40 km resolution and 10-day forecasts), for the regional scales (10 km resolution and 3-day forecasts) and shelf scales (4 km resolution and 3- days hindcasts);
- the development of a new generation Biochemical Flux Model-BFM that is coupled with the physical forecasting models of the Adriatic Sea and Eastern Levantine and Aegean Sea;
- the implementation and testing of data assimilation techniques in the ecosystem models.

The end-user component that exploit the nowcasting/forecasting products involve development of RT interfaces with circulation forecasts of:

- oil-spill forecasting models;
- floating-object forecasting models;
- contaminant-fate prediction models;
- relocatable models for fast emergency intervention at sea;
- pelagic fish data sets for stock assessment and management in the open sea and Adriatic shelf areas;
- User-oriented Visualization Tool (UVT) for further dissemination of MFSTEP products;

In addition, an economic value analysis has been carried out on the present MFSTEP products end-user base and on the total costs of the MFSTEP system.

Scientific achievements: The third year lifetime of the Project (1 March 2005-31 May 2006) coincides with the post-TOP phase that was mainly dedicated to continuing to run all the components of the observing and forecasting system and to performing the scientific assesment of the system. The operational forecasting system for the Mediterranean Sea has been operationally tested and assessed in its three main components: a) a RT Observing system; b) a numerical forecasting systems at the basin scale and for the sub-regional areas; c) the forecast products dissemination/exploitation system.

The Observing system components running operationally progressively since summer 2004 are:

1) a SOOP-VOS system composed of 9 tracks with 12 nautical miles' resolution and full profile transmission;

2) an altimeter RT data analysis system using four available altimeter sensors for sea surface elevation anomalies, RT analysis of AVHRR with the production of daily SST fields and RT Scatterometer wind analyses blended with NWP products;

3) 23 MedARGO floats deployed at 350m parking depth, 700 m profiles and 5 days cycle (every 5 cycles a 2000 m profile is collected);

4) a glider experiment in the Ionian Sea (a coastal glider sampling down to 200 m and a deep glider sampling as a virtual mooring down to 950 m) that collected over 4000 T, S, O2 profiles;

5) a moored buoy network (M3A) (E1-M3A in the south Aegean Sea, E2-M3A in the Southern Adriatic Sea, W1-M3A in the Ligurian Sea).

The RT data dissemination network works properly on a weekly time scale.

As far as it concerns the technological development, MFSTEP has developed a multiple launcher which consists of a launching system managed by software allowing the selection of the XBT probes and the launch at defined sampling intervals.

A new sensor, the T-Flap (Temperature and Fluorescence LAunchable Probe) has been tested at sea to measure temperature and chlorophyll profiles from SOOP-VOS. Several tens of prototypes have been produced and few tried at sea.

A new sliding vehicle (SAVE) from SOOP-VOS was designed, in order to collect physical and optical profiles in the upper 200 m of the water column. SAVE slides along a cable between the surface and a depressor, that is towed at a fixed depth, and is composed of an underwater unit, an onboard unit and a data transmission system.

The OSSE experiments have shown the complementarities of the four elements of the observing system and the optimal sampling scheme for the Mediterranean basin scale circulation. Innovative assimilation of float trajectories from MedARGO has been completed so that for the first time it is possible to show the benefit in assimilating the ARGO floats trajectories together with the profiles.

The Modelling system component is now composed of:

1) An upgraded Reduced Order Optimal Interpolation Scheme that assimilates daily SLA, XBT, ARGO and SST at basin scale. This is the first daily assimilation cycle system working nowdays.

2) 10-day basin scale forecasts done with an OGCM at 6.5 km resolution and 71 levels. The forecasts have been available in real time during and after the Targeted Operational Period-TOP.

3) 5-days regional forecasts done with OGCM at 3 km resolution in four sub-regions nested in the basin scale model: North-Western Mediterranean, Sicilian Strait, Adriatic Sea and Levantine-Aegean Sea. 5-days shelf (1,5 km resolution) forecasts done with nested OGCM in the sub-regional models (Gulf of Lion, Malta Shelf, Cyprus Coastal Ocean Model, SE Levantine Shelf). 6 shelf forecast models implemented for the first time (Turkish coasts, Northern Adriatic, Northern Aegean, Cretan Sea, Catalan Sea 1 & 2)

4) operational weather LAM forecasts at 10 km resolution used to force the sub-regional nested models;

5) three-dimensional ecosystem model composed of a general Biochemical Flux Model-BFM coupled to the Adriatic Sea, Eastern Levantine and Aegean Sea , and Mediterranean Sea models. The BFM is a new code for open ocean and coastal biochemistry based upon a biomass and functional group representation of the marine food web;

6) data assimilation techniques implemented in ecosystem models for biochemical observations. The singular Evolutive Extended Kalman filter (SEEK) has been coupled to the biochemical flux model and initial experiments with assimilation of ocean colour data show the overall consistency of the approach.

7) Advanced data assimilation tools developed for shelf models allow the initialization of nested models from basin scale model outputs and the assimilation of local observations. This is a very important scientific advancement that it is believed to have a large impact on the extension of the predictability limit in the coastal areas.

The end-user applications show the value of using circulation forecast products for the most accurate prediction of oil spill and contaminant dispersion in the open ocean and coastal seas.

Socio-economic relevance and policy implications: MFSTEP is contributing to the improvement of the ocean monitoring and forecasting capabilities in the Mediterranean Sea that should be at the basis of an efficient, scientifically-based management of the Mediterranean marine environment. This will indirectly contribute to reducing pollution in the open sea and coastal areas, to developing plans for management of environmental emergencies, to increasing safety of maritime transport and the sustainable development of fisheries.

MFSTEP applications have been designed to meet the needs of international conventions and agreements in the Mediterranean Sea. In particular, MFSTEP will contribute to organizing the response against oil and other contaminants pollution in the Mediterranean Sea as defined by the Barcelona Convention.

MFSTEP is contributing to the EU initiative GMES (Global Monitoring for Environment and Security), based on an integrated approach for the routine acquisition of environmental data at the global scale, using both space- and ground-based monitoring systems. GMES refers explicitly to the fact that potential components of such a system already exist (local/regional environmental forecasting systems) and MFSTEP could offer the regional ocean system component of GMES for the Mediterranean. MFSTEP is already inserted in the GMES MERSEA Integrated Project (started in April 2004) which will coordinate the European activities in operational oceanography for the European Seas and the global Ocean.

Conclusions: MFSTEP has developed and consolidated a short-term forecasting system for the Mediterranean basin scale and its coastal areas, the system provides continuous monitoring of the flow field evolution and its changes and forecasts for 5-10 days. Information is delivered by a operational integrated system that is at the basis of coastal algal biomass variability forecasts, pollutant dispersion monitoring and forecasting and the formulation of indicators of ecosystem health and change.

This system, through the continuous delivering of information from the observing and forecasting system, also provides the meaning to improve our understanding, and our capability to model accurately the physical processes with an incremental approach and the optimal usage of all information.